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(71) Applicants
Anthony John Asbury,
30 Impala Close, Norwich, Norfolk NR6 7PN.
Deryck Charles Allen,
19 Quebec Road, Thorpe Hamlet, Norwich, Norfolk

(72) Inventor
Anthony John Asbury

(74) Agent and/or Address for Service
William Jones,
Willow Lane House, Willow Lane, Norwich, Norfolk
NR2 1EU

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G1A
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(54) Device for detecting displacement

(57) A device for monitoring displacement of an object (6) comprises an optical interface (3,4) including a first member (4) for producing a spectrum from a beam of light, and a second member (3) comprising an optical mask having alternate trnsparent and opaque bands, the thickness of the bands being chosen according to the required accuracy of measurement; a source (12) emitting a light beam to a means (7) which transmits the beam towards the optical interface (3, 4) such that a spectrum is produced by the first member (4), parts of which are masked by the second member (3), one of the first or second optical interface members or the beam transmitting means being mounted on the object (6) such that displacement of the object (6) causes relative displacement between the second member (3) and the spectrum produced by the first member (4), a lens (5) arranged to concentrate the partial spectrum produced by the optical interface into a beam, which is then transmitted to a monitoring station (2), the monitoring station (2) including means (9, 10, 11) to detect which parts of the spectrum are not masked by the second member and a microprocessor (14) to calculate the displacement of the object (6) with respect to the fixed reference point from the parts of the spectrum masked by the optical mask.

Such a device a device may be used as part of many different instruments in which movement or vibration is measured. Such instruments include many different types of transducer or, alternatively, microphones or thermometers.

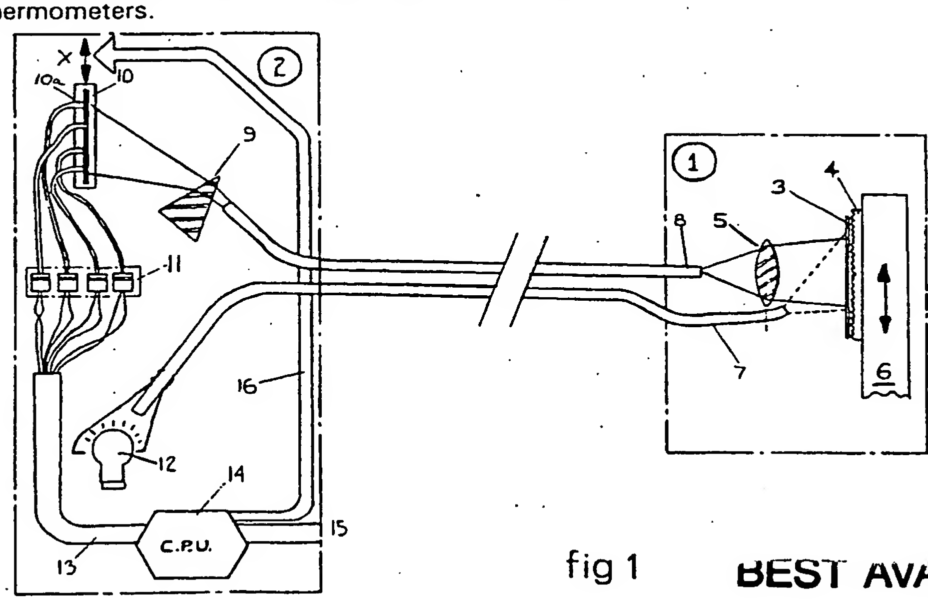

fig 1

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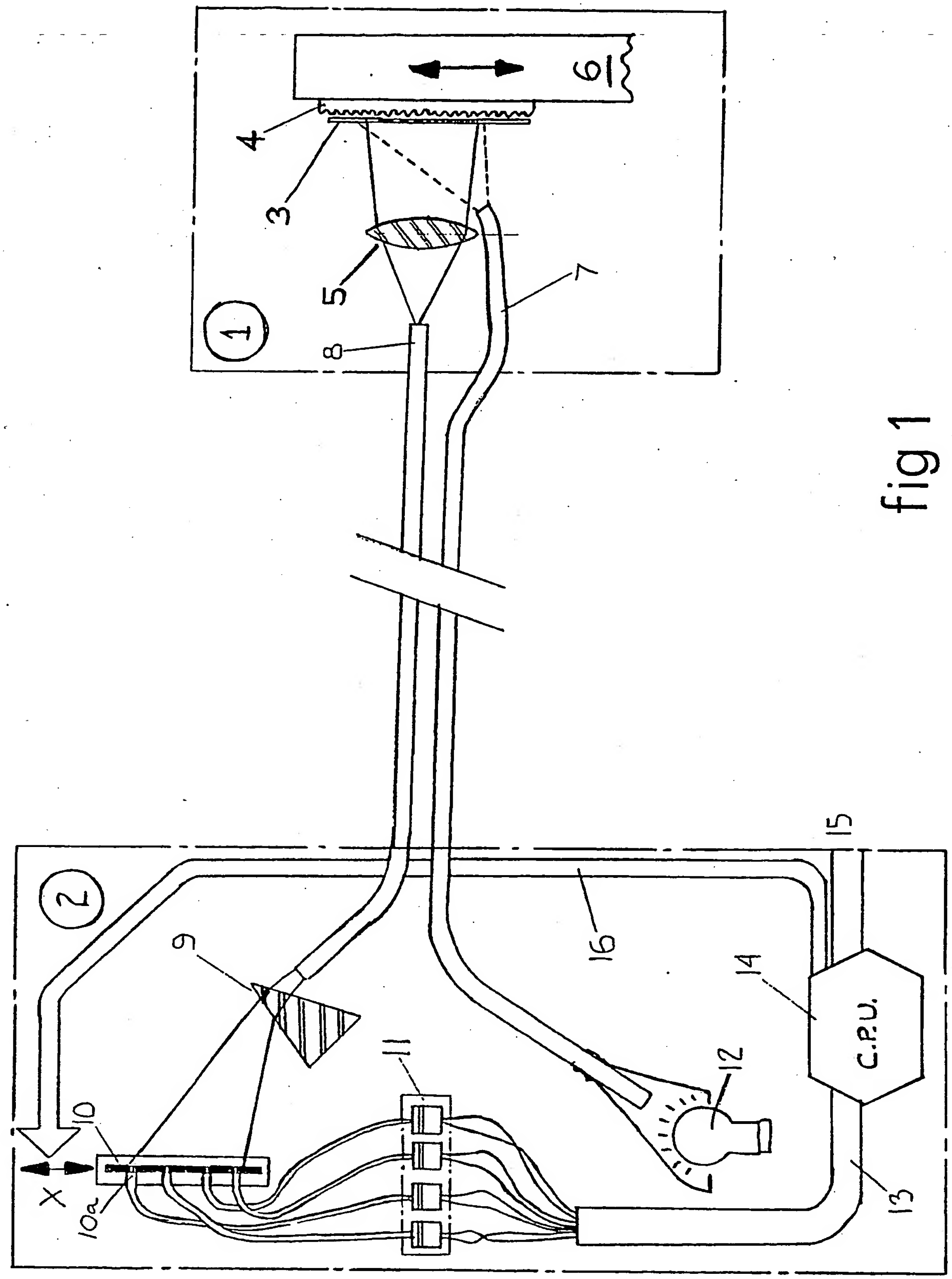

fig 1

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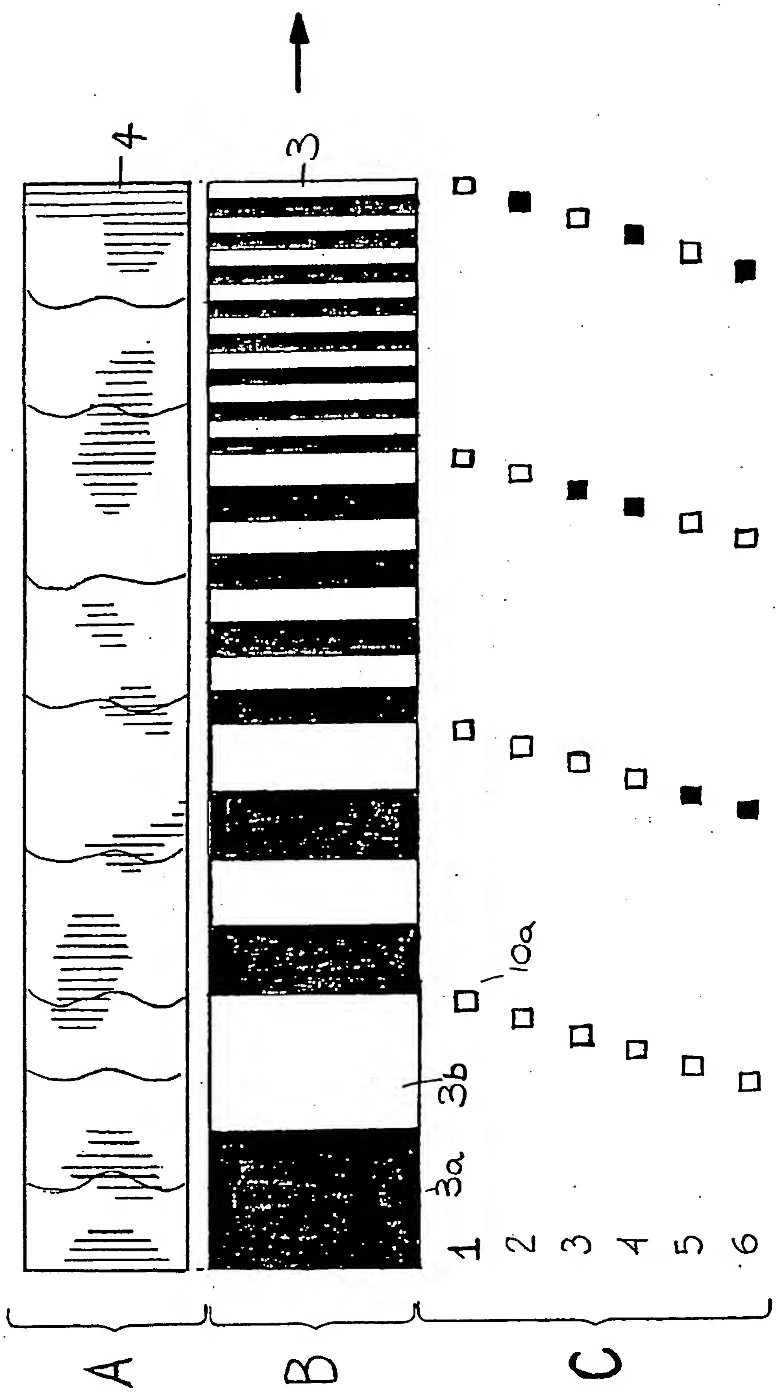

fig 2

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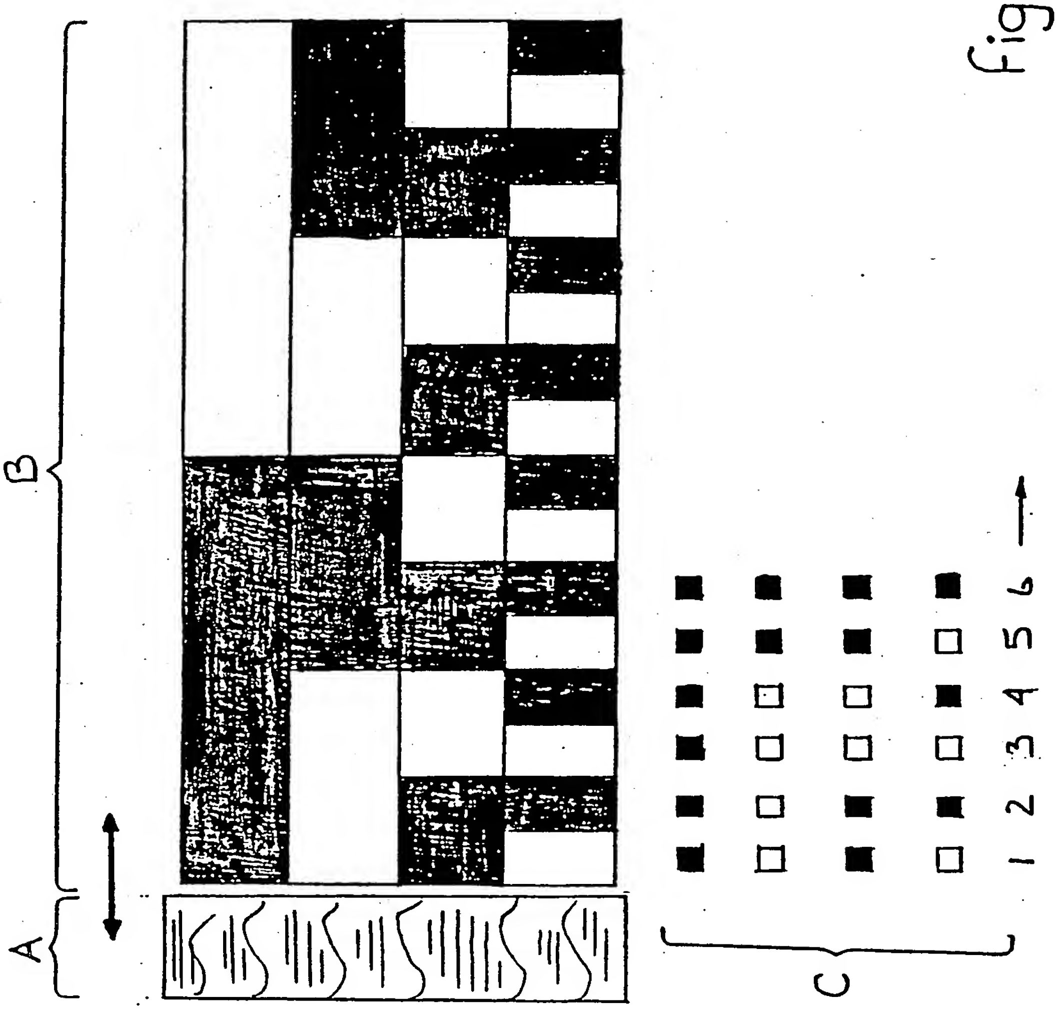

Fig 3

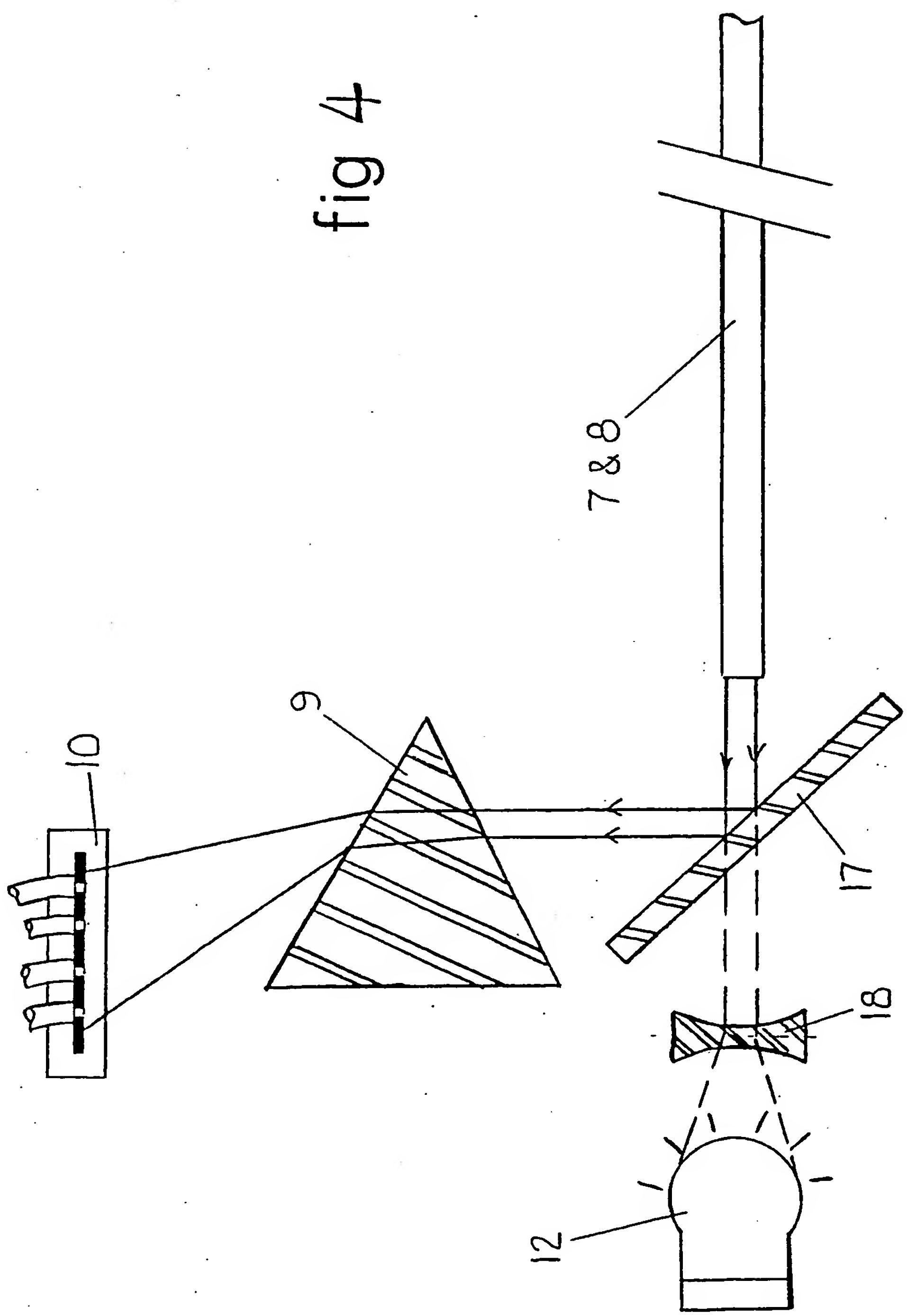

fig 4

SPECIFICATION

Device for detecting displacement

Field of the Invention

The invention relates to a new device for measuring the displacement of an object with respect to a fixed reference point.

Such a device may be used as part of many different instruments in which movement or vibration is measured. Such instruments include many different types of transducer or, alternatively, microphones or thermometres.

Summary of the Invention

According to the invention there is provided a device for monitoring displacement in at least one direction, of an object with respect to a fixed reference point, the device comprising

an optical interface including two members, a first member comprising means to produce a spectrum from a beam of light, and the second member comprising an optical mask consisting of a series of parallel opaque and non reflective bands, at least part of the bands lying perpendicular to said one direction, the bands being separated by optically transparent regions, the thickness and spacing of the bands and the regions being chosen according to the accuracy to which the displacement is to be measured;

a light source which produces a beam of light and transmits it to a beam transmitting means which projects the beam of light towards the optical interface such that a spectrum is produced by the first member, parts of which are masked by the second member;

one of the first or second optical interface members or the beam transmitting means being mounted on the object such that displacement of the object causes relative displacement between the second member and the spectrum produced by the first member;

a lens arranged to concentrate the partial spectrum produced by the optical interface into a beam, which is then transmitted to a monitoring station, the monitoring station including means to detect which parts of the spectrum are not masked by the second member and a microprocessor to calculate the displacement of the object with respect to the fixed reference point from the parts of the spectrum masked by the optical mask.

Thus, the mask itself may be mounted on the object with the beam transmitting means and spectrum producing means fixed. Alternatively the spectrum itself may move. This can be done either by mounting the spectrum producing means on the object or mounting the beam transmitting means on the object such that the angle and position of incidence of the beam on the spectrum producing means may change, thus shifting the position of the spectrum produced.

Thus, the important feature of the device is that the displacement of the object causes relative movement between the spectrum and the second member of the optical interface. This means that the part of the spectrum masked by the optical mask will change according to the relative positions of the object and the fixed reference point. Thus, those frequencies of light will be omitted from the beam of light transmitted to the monitoring station. When this beam is analysed it will be found that the beam will have some frequencies missing. By careful measurement of these frequencies present and absent, the position and thus displacement of the object may be calculated by the microprocessor by comparison with the starting reference spectrum.

Preferably the means to detect the parts of the spectrum not masked include a second spectrum producing means through which the beam is passed to produce a part spectrum onto a screen, the screen including sensor means coupled to the microprocessor.

The parts of the spectrum missing correspond to the parts of the spectrum masked by the second member of the optical interface.

The first member of the optical interface may be a standard prism which is mounted fixed relative to a fixed reference point.

However it is preferred that the first member comprises a diffraction grating. In this case it matters not whether the diffraction grating moves, the spectrum produced will remain stationary.

Thus, it is possible for the first and second member of the optical interface to move together with the object. In this case preferably the optical interface is manufactured as a single unit of a sandwich of a diffraction grating and optical mask.

Alternatively such a sandwich may be mounted fixed with beam transmitting means being mounted on the object. In this way the position of the light on the optical interface and therefore position of spectrum in relation to the mask changes.

In such a case preferably the beam transmitting means includes a mirror. This is a useful arrangement for measuring the movement of a diaphragm in a transducer, and in particular in a microphone.

The optical interface may be arranged such that the beam of light passes first through the first member onto the second member or vice versa.

Since the method of transmitting the signals representing the movement of the object are transmitted from the object to the monitoring station by light only, it is possible to produce a device which comprises a first station where the optical interface and the beam transmitting means are positioned, where there are no electrical components. This is a preferred arrangement since it means that the device may

be used in hazardous and remote situations or, most usefully, under water.

In this case it is preferred that the light source is positioned at a second monitoring station. In some embodiments, it is possible for the light to be transmitted directly through all the components but preferably the beam of light is transmitted from the light source to the optical interface via beam transmitting means including an optical fibre and the beam of light is transmitted from the lens to the second spectrum producing means by an optical fibre.

In this case, the device can be constructed so that the first station where there are no electrical components may be remote from the second station where the monitoring of the objects displacement takes place.

Thus, the device may be used very conveniently in situations under water and this can be particularly useful in diving and oil drilling operations. In this case the device may be used to measure displacement in any instrument where a parameter to be measured may be converted to displacement, for example a microphone, a load pressure or temperature transducer.

In the case where the light is transmitted via fibre optics, it is preferred that the same optical fibre is used to transmit the light from the light source to the optical interface and to transmit the light from the optical interface to the second spectrum producing means.

A very simple and convenient device may be produced for measuring displacement on one axis only. In this case, the optical mask comprises a series of parallel bars all perpendicular to the direction in which relative displacement between the spectrum and the mask may occur.

One possible arrangement for the bars is to have a first bar and first transparent region of a first constant thickness adjacent a second set of bars and regions consisting of two bars and two transparent regions, each of a second thickness equal to half the thickness of the first thickness, adjacent a third set of bars and regions, comprising four bars and four transparent regions each of thickness equal to half the second thickness. This pattern may be continued dependant upon the accuracy of measurement of displacement required the range (length) of displacement to be measured.

The pattern may be arranged such that the sets of bars are adjacent one another along the length of the mask.

Alternatively, the sets of bars may be adjacent along the width of the mask.

The advantage of using such masks is that the number of sensors required on the screen at the monitoring station need only be equal to the number of different sets of bands and regions on the mask, spaced apart by the distance equal to the thickness of one whole set. Each sensor measures a spectrum width equal to the width of the smallest band In this case the signals sent to the microprocessor will be in the form of a binary digital signal measuring the presence or absence of the spectrum on that part of the screen which means that the displacement may easily be calculated.

It is possible to produce a device which can be used to measure displacement in more than one direction. In this case, the mask may be in the form of an interference pattern such as Newtons rings. In this case the microprocessor and sensing means on the screen will be much more complicated.

Alternatively the device may measure displacement in two perpendicular directions simultaneously. This may be done by splitting the beam at the beam transmitting means into two using polarising filters, colour filters, spectrum division or other similar means. The device will then include two separate masks each oriented to measure displacement in one of the required directions.

The device may be arranged to measure rotation. This is done by using a mask in which each band forms an arc. The mask includes a series of rings, with each ring including a set of opaque and transparent bands. Relative rotation of the spectrum and the mask may in this way be measured.

The first member of the optical interface need not be a prism or diffraction grating. It is possible for it to comprise a reflecting surface or transparent medium marked with a spectrum so that a beam having passed through or been reflected from the member will include a spectrum which can move relative to the mask.

Brief Description of the Drawings.

Two examples of devices in accordance with the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic view of a first system;

Figure 2 is a schematic view showing the operation of the optical interface;

Figure 3 is a schematic view showing an alternative form for the second member of the optical interface; and,

Figure 4 is a schematic view of part of a second example of a device.

Description of the Preferred Embodiments

A first device is shown in Figure 1 and comprises a first station 1 where the movement of an object 6 is to be monitored and a remote second station 2 where the actual displacement is calculated.

At the first station 1 is an optical interface which comprises 3 and 4. A first member 4 consists of means to produce a spectrum which, in this case, is a diffraction grating. The second member 3 comprises an optical

mask which is shown in more detail at B on Figure 2. The mask comprises a series of opaque non-reflective bands 3A spaced by transparent zones 3B.

The optical interface sandwich 3 + 4 is mounted on an object 6 of which the displacement is to be monitored.

A source of white light 12 is situated at remote station 2 and produces white light and transmits it via beam transmitting means consisting of an optical fibre 7 to diffraction grating 4 which produces a spectrum which is transmitted through mask 3 to a lens 5 which concentrates the spectrum into one beam so that it can be transmitted via optical fibre 8 to the monitoring station 2.

At the monitoring station 2 the beam of light from optical fibre 8 passes through a second spectrum producing means 9 which in this case comprises a prism. This produces a part spectrum on screen 10. At screen 10 are four sensing means 10A equally spaced on the screen which send signals to a light sensor plate 11 and via 13 to microprocessor 14 which can then calculate the displacement of object 6.

Figure 2 shows in more detail how the displacement of the object 6 is calculated. 'A' represents the diffraction grating 4 which produces a spectrum, part of which is masked by the diffraction grating 3.

'C' represents the signals detected at the sensing stations 10A. The sensing stations detect only absence or presence of a signal.

Movement of the optical interface 3, 4 to the left is represented on Figure 2 as relative movements to the right hand side of the mask 3. In this case movement of the diffraction grating does not cause movement of the spectrum produced.

The first row of signals represent a typical starting or calibration point representing no displacements where each of the sensing stations 10A detect a signal presence. The screen 10 is preferably arranged such that before use it can be calibrated accurately so that at the desired fixed reference point the screen may be moved in direction 'X' as shown in Figure 1 until each of the sensing stations 10A monitor a signal.

The optical mask is arranged such that it comprises four sets of bands. The first set of bands comprises one band and one transparent region, each of a first thickness. The second set is adjacent the first set and comprises two bands and two regions each of thickness equal to half the thickness of the first band. The third set comprises four bands and four regions of thickness equal to half the second bands and regions. The fourth set comprises eight bands and eight regions each of thickness equal to half the thickness of the third set of bands and regions.

If relative movement equal to the width of one band of the fourth set is produced, then one only of the sensors IOA cannot sense a signal. As can be seen in Figure 2, if the sensors 10A and sensing plates 11 are arranged as binary signals, they will give a read out equal to the number of units the object has moved relative to the fixed reference point.

The scale shown will permit monitoring of 16 separate displacement positions over the determined range. If further accuracy is required, further sets of bands of even smaller thickness may be added to the mask 3.

Figure 3 shows an alternative form of mask. In this the mask again comprises four sets of bands similar to those shown in Figure 2. Here however the sets are arranged adjacent one another along the width of the mask instead of all the bands lying along one strip parallel to one another.

This measures displacement in exactly the same way producing a binary signal. However here the mask can be arranged perpendicular to the direction of the spectrum and therefore the length of the mask is not limited by the length of the spectrum produced.

In a second example of the device the same fibre optic 7 and 18 is used to both transmit light from the light source 12 to the optical interface 3, 4 and to transmit light from optical interface 3, 4 back to prism 9. In this case, the light source 12 transmits light via a concave lens 18 and through then section flat transparent glass sheet 17. The transparent sheet 17 is arranged at such an angle that the modified beam returning from the optical interface is reflected rather than transmitted through the glass through 90° so that it can then pass through prism 9 to the screen 10.

It will be appreciated that the source of white light 12 may equally comprise a source of any light of a combination of frequencies which can thus produce a spectrum.

In alternative embodiments of the invention the means to analyse the spectrum at the monitoring station may comprise a colour sensitive optical transducer such as that sold by Sharp.

CLAIMS

1. A device for monitoring displacement in at least one direction, of an object with respect to a fixed reference point, the device comprising an optical interface including two members, a first member comprising means to produce a spectrum from a beam of light, and the second member comprising an optical mask consisting of a series of parallel opaque and non reflective bands, at least part of the bands lying perpendicular to said one direction, the bands being separated by optically transparent regions, the thickness and spacing of the bands and the regions being chosen according to the accuracy to which the displacement is to be measured;

a light source which produces a beam of

light and transmits it to a beam transmitting means which projects the beam of light towards the optical interface such that a spectrum is produced by the first member, parts of which are masked by the second member;

one of the first or second optical interface members or the beam transmitting means being mounted on the object such that displacement of the object causes relative displacement between the second member and the spectrum produced by the first member;

a lens arranged to concentrate the partial spectrum produced by the optical interface into a beam, which is then transmitted to a monitoring station, the monitoring station including means to detect which parts of the spectrum are not masked by the second member and a microprocessor to calculate the displacement of the object with respect to the fixed reference point from the parts of the spectrum masked by the optical mask.

2. A device according to claim 1, in which the means to detect the parts of the spectrum not masked include a second spectrum producing means through which the beam is passed to produce a part spectrum onto a screen, the screen including sensor means coupled to the microprocessor.

3. A device according to Claim 1, in which the means to detect the parts of the spectrum not masked comprises a colour sensitive optical transducer.

4. A device according to any one of the preceding claims, in which the first member of the optical interface is a standard prism mounted fixed relative to a fixed reference point.

5. A device according to any one of claims 1, 2 or 3, in which the first member comprises a diffraction grating.

6. A device according to Claim 5, in which the optical interface is manufactured as a single unit of a sandwich of a diffraction grating and optical mask.

7. A device according to claim 6, in which the single optical interface unit is mounted on the object such that both the first and second members of the optical interface move with the object.

8. A device according to any one of the preceding claims, in which the beam transmitting means includes a mirror arranged to reflect a beam of light from the light source towards the optical interface, in which the mirror is mounted on the object.

9. A device according to any one of the preceding claims, in which the device comprises a first station including the optical interface and the beam transmitting means, and a second station including the light source and the monitoring station.

10. A device according to claim 9, in which the beam transmitting means includes an optical fibre extending from the second station to the first station and the beam of light is transmitted from the first station to the second station by an optical fibre, such that the first station where measurement of movement of an object occurs may be remote from the second station.

11. A device according to claim 10, in which the same optical fibre is used to transmit the light from the light source to the optical interface and to transmit the light from the optical interface to the monitoring station.

12. A device for monitoring displacement in at least one direction, of an object with respect to a fixed reference point arranged substantially as described herein with reference to, and as illustrated in Figures 1 and 2 of the accompanying drawings.

13. A device for monitoring displacement in at least one direction, of an object with respect to a fixed reference point arranged substantially as described herein with reference to, and as illustrated in Figures 1 and 2, when modified in accordance with Figure 3 of the accompanying drawings.

14. A device for monitoring displacement in at least one direction, of an object with respect to a fixed reference point arranged substantially as described herein with reference to, and as illustrated in Figures 1 and 2, when modified in accordance with Figure 4 of the accompanying drawings.

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